# SPECTRUM AND TECHNOLOGY ISSUES FOR MICROWAVE BACKHAUL IN EUROPE

November 2010

Sponsored by Cambridge Broadband Networks

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## EXECUTIVE SUMMARY

Microwave backhaul is extensively used by European mobile operators. But as 3G/4G traffic grows, operators must find ways to increase the capacity of backhaul networks and must therefore review whether microwave networks can deliver the performance required in a cost effective way. We believe that it can – and that microwave will retain its importance as a backhaul bearer, alongside a growing use of (more expensive) fibre. But operators must make sure that they deploy appropriate technologies to make the most efficient use of spectrum resources when replanning microwave backhaul networks. This will include using point-to-multipoint (PMP) systems in areas where spectrum for conventional point-to-point (P2P) links is becoming limited and expensive.

Our research into spectrum availability has shown that this is increasingly the case in some areas and countries. Some of the frequency bands currently used for P2P links, such as the sub-10, 13, 15 and 23 GHz bands, are becoming saturated in some places, particularly in urban areas. Demand for wider channels (e.g. 28 MHz or 56 MHz channels), which increase the capacity that can be delivered, is rising, and will continue to grow as operators roll out HSPA+ and LTE.

Many operators are considering moving to higher frequencies, such as in the 40 and 80 GHz bands, which can offer increased bandwidth and capacity, and attractive spectrum fees compared to lower frequency links. But the distance links can cover becomes increasingly limited as frequency rises, which adversely affects the capital costs of deploying links and ongoing costs such as site rental and maintenance. In addition, equipment for the 80 GHz band is expensive compared to that for the most commonly used PTP frequency bands.

PMP technologies offer operators a cost-effective way to expand their microwave backhaul capacity as their capital and operational costs, spectral efficiency, and speed and flexibility of deployment compare well with alternative technologies, while offering similar performance benefits. Mature PMP backhaul solutions are commercially available, and have been successfully deployed in the Middle East, Africa and in Europe by major operators.

Existing multipoint spectrum, such as in the 26 and 28 GHz fixed wireless access (FWA) bands, is under-utilised and is generally cheap to obtain. Unused frequencies could be used for backhaul applications, subject to regulatory approval. Regulators are increasingly adopting a technology neutrality approach to spectrum licensing, and are likely to be amenable to allowing a more liberalised use of these bands.

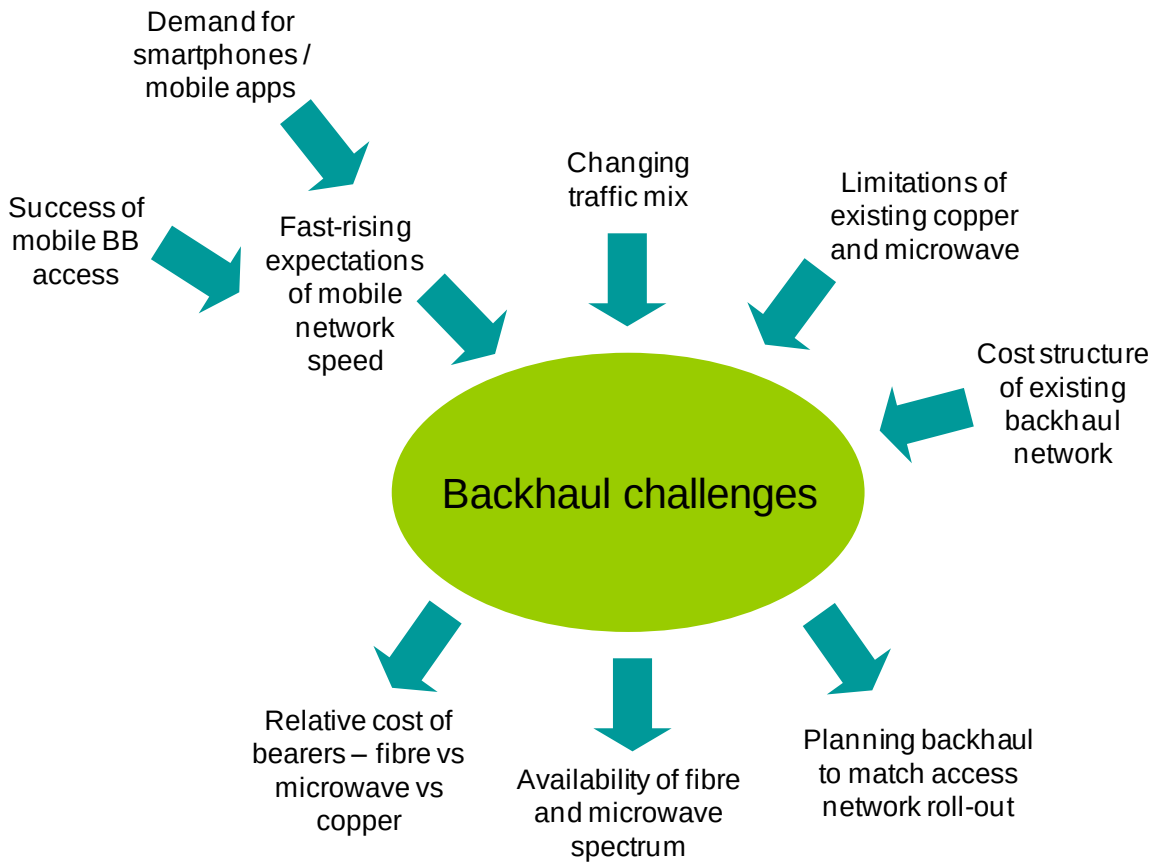
Operators should keep an eye open for auctions of suitable frequencies (e.g. in the 26, 28, or 32 GHz bands) on a geographic basis, with technology and service neutral licensing conditions. This approach was adopted by the UK, for example, for its auction in 2008 of spectrum in the 10.5, 28, 32 and 40 GHz bands. Some countries, including Germany, have adopted EU guidelines for the block assignment of spectrum in the 32 GHz band, and made it available for PMP applications.

The availability of low-cost, sub-40 GHz multipoint spectrum in many markets, combined with mature PMP technologies proven in commercial deployments, provides an opportunity for operators to maximise the effectiveness of their microwave backhaul during the replanning process that is necessary to deal with increasing capacity requirements. In particular, the main multipoint bands of 26 and 28 GHz bands could offer an attractive combination of range, capacity and cost benefits for operators' backhaul extension.

## THE BACKHAUL CHALLENGE

One of the biggest challenges for operators' wireless network evolution is catering for the explosion in traffic (and particularly packet data) that is being brought about by the rapid adoption of data services, such as mobile broadband access and smart phone based mobile applications. Operators have had to fundamentally re-evaluate their backhaul strategies, in order to expand their transmission networks cost-effectively. Figure 1 depicts these and other elements of the backhaul challenge.

***Figure 1: The backhaul challenge [Source: Innovation Observatory]***




In Europe, microwave technologies play an extensive role in backhaul provision. This paper considers the role of microwave backhaul in addressing the backhaul challenge, and in particular trends in the demand and supply of microwave spectrum to cater for operators' future needs.

Almost all microwave backhaul in the region is based on PTP technologies, and these will continue to be important in the development of backhaul provision. While the spectrum bands used for PTP fixed links are becoming increasingly saturated, multipoint spectrum is by contrast under-utilised in many markets. We examine the opportunities this presents for operators to deploy PMP backhaul solutions as part of their backhaul expansion strategy.

In preparing this paper, we have drawn on the views of regulators and operators in key European markets regarding the availability of microwave spectrum and the technologies suitable for microwave backhaul.

# TRENDS IN WIRELESS NETWORKS

Mobile broadband has been the unforeseen success story for 3G networks. The introduction of dongle-based mobile broadband services spurred an unprecedented growth in data traffic, putting pressure on the backhaul capabilities of operators' networks as well as on operator margins.

Traffic will continue to grow significantly in volume as operators evolve their networks to HSPA+ and LTE, driven by mobile data services such as dongle- and laptop-enabled mobile broadband and by smart phone-based services. This will require a step change in the backhaul capacity required, as well as technologies capable of supporting an ever-increasing proportion of IP packet data.

## 3G/4G NETWORK DEVELOPMENT

Continuing growth in demand for mobile broadband services, based on HSPA-enabled net books, dongles and smart phones, is driving operators to upgrade their radio access networks to offer enhanced data rates to users.

2010 has seen increasing numbers of 3G operators in Europe introduce HSPA+ upgrades, to increase theoretical peak downlink data rates initially to 21Mbit/s. The HSPA+ roadmap supports future enhancements in downlink data rates to 28Mbit/s and 42Mbit/s within the next two to three years.

There is strong momentum, too, towards the introduction of LTE networks in Europe. LTE promises an improved user experience, with peak downlink data rates of 100Mbit/s where the technology is deployed in optimal 20MHz carriers. TeliaSonera launched the world's first LTE services in late 2009 in Norway and Sweden, and deployments by other European operators are expected in 2011.

The evolution of high-speed mobile broadband networks in Europe will be enabled by the release of new radio access spectrum in the 2.6 GHz and digital dividend 800 MHz bands.

- The 2.6 GHz band offers abundant FDD spectrum suitable for building LTE networks. In addition, there are TDD frequencies in the 2.6 GHz duplex gap, which will drive the development of mobile WiMAX (IEEE 802.15e) or TD-LTE based networks. After numerous delays over the past three years, 2.6 GHz spectrum is now being released in a growing number of countries in Europe. Auctions have concluded in Austria, Denmark, Finland, Germany, Norway, the Netherlands, and Sweden, and other countries such as Belgium, France, Poland and UK are also preparing to release this band.

- For broader LTE coverage, new spectrum that is becoming available as a result of the migration of TV broadcasting to digital technologies (the 'digital dividend') will be vital. In Europe, the 800 MHz (792-860 MHz) band has been identified for the development of mobile broadband services. Many EU countries have already committed to making this band available, and the first auctions have taken place in countries such as Germany.

The release of spectrum in the 2.6 GHz and 800 MHz bands could provide opportunities for new entrants in mobile network operation. Cable operators and MVNOs, for example, may be motivated to participate in spectrum auctions, in order to enrich their service offerings. In the Netherlands, for example, where part of the 2.6 GHz band was reserved for new entrants, Tele2 and a consortium of regional cable operators both acquired mobile licences. Similarly, interest has been reported among cable operators in Spain in participating in the forthcoming 2.6 GHz auction. The availability of TDD

frequencies in the 2.6 GHz duplex gap will also create opportunities for new players to develop mobile WiMAX or TD-LTE networks.

While in some markets in Europe we expect to see the emergence of new mobile network operators, this will by no means be a universal trend. The 2.6 GHz/800 MHz spectrum auction in Germany produced no new entrants, and in some other markets, including the UK, consolidation is taking place, either in terms of network sharing or through mergers among existing players.

## THE IMPACT ON BACKHAUL NETWORKS

To overcome bottlenecks in the cell site backhaul and aggregation layers, mobile operators will need to significantly upgrade their backhaul capacity. For example, most industry estimates suggest that for LTE deployments operators will require peak capacities of 50-100Mbit/s per cell site, and higher capacities for some traffic hotspots. Average capacities will be lower.

In addition to enhancing backhaul capacity, operators must prepare their backhaul networks for a changing mix of traffic. The transition to all-IP technologies such as LTE and mobile WiMAX (IEEE 802.15e) means that the backhaul network will need to cater for an increasing volume of packet data over time, whilst at the same time being able to handle legacy circuit-switched traffic.

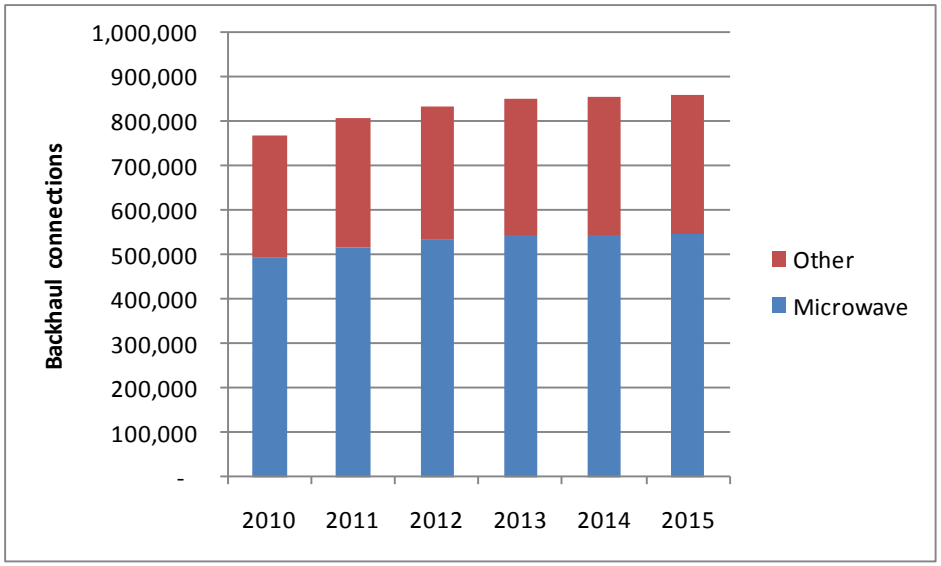
While packet data will dominate the traffic mix in future, the transition to IP is expected to be protracted, as legacy voice services will continue to need to be supported for a number of years. GSM networks are expected to remain in service in most parts of Europe until at least 2018-2020, and most LTE networks will support data-only traffic initially, with VoIP being introduced at a later stage once suitable devices are ready.

Flexibility and speed of deployment are also important requirements for backhaul technologies in the transition to LTE. LTE will not be ubiquitous in the network for many years, and so operators will require solutions that can be easily deployed as the network expands and provide the flexibility to cater for growth in demand at high-traffic cell sites. Operators will be keen to manage data traffic growth effectively, and to avoid the kinds of congestion and performance issues that were encountered when mobile broadband services were introduced.

## EVOLUTION OF APPROACHES TO BACKHAUL PROVISION

European operators typically use a mix of backhaul bearer technologies, including copper, fibre, microwave and, in a few cases, satellite. Some operators are using DSL as a stop-gap measure to increase backhaul capacity, but this is not a long-term solution. In the past, microwave and copper E1s predominated in the backhaul network, but in recent years, there has been a significant shift away from copper, because of the high operational costs of maintaining additional connections. Copper-based E1s are increasingly being replaced by fibre connections, and to a lesser extent by packet microwave links. We expect the use of microwave backhaul bearers in Europe to remain significant in future, accounting for over half a million backhaul connections by 2015, as shown in Figure 2.

*Figure 2: Forecast backhaul connections in Europe [Source: Innovation Observatory]*




Fibre is an attractive option for backhaul in terms of capacity and opex, and there is a trend towards operators replacing copper connections with fibre, especially for trunk connections. However, fibre has the drawback of being very expensive and time-consuming to install. It is not a cost-effective solution for rural sites, where there may be lengthy distances between the cell tower and trunk network. In addition, fibre backhaul may not be suitable for some urban cell sites, particularly for connecting base stations mounted on street furniture.

One of the key benefits of microwave backhaul solutions is that links can be quickly deployed to cater for growth in traffic, and it is a cheaper solution to deploy than fibre or copper. However, capacity is more limited than with fibre, and the available spectrum resources are becoming more and more heavily utilised. Demand for wider bandwidths (e.g. 28 MHz or 56 MHz channels), which increase the capacity that can be delivered, is rising, and will continue to grow as operators introduce HSPA+ upgrades and roll out LTE.

Microwave equipment vendors are introducing a variety of capacity-enhancing techniques into their products, including:

- polarisation diversity schemes, such as co-channel dual polarisation
- using multiple radios per link
- higher-order modulation schemes, which increase capacity but are more prone to rain fade (degradation of radio signals arising from water absorption)
- packet header compression, which reduces packet or frame size to enable more traffic to be carried over the same amount of spectrum
- statistical multiplexing, a technique which reduces the bandwidth used to carry traffic.

Several mobile operators are engaged in upgrading their microwave backhaul technologies, to increase capacity and optimise the use of their spectrum allocations. Vodafone, for example, is exploring the potential of Ethernet microwave and adaptive modulation to boost capacity and make more economical use of spectrum.

Interest is also growing among operators in backhaul sharing, as a means of lowering overall network costs. Sharing masts for hosting microwave antennas is the most common arrangement. For example, Telefónica O2 and Vodafone's ten-year network sharing agreement for selected European markets includes mast-sharing for microwave backhaul in Germany and a commitment to explore opportunities for backhaul sharing in other markets.

Deeper forms of backhaul sharing, such as sharing of microwave frequencies (which would enable a more efficient overall use of the spectrum), tend to be restricted by regulation. In some circumstances, requests for sharing the transmission network may be permitted. For example, Tele2 and Telenor are building a joint transmission network, comprising fibre and microwave technologies, as part of their joint venture to build a nationwide LTE network in Sweden. However, because of the regulatory hurdles, we do not expect any significant increase in microwave spectrum pooling in Europe. This will increase pressure on the existing microwave spectrum resources.

## SUPPLY AND DEMAND FOR MICROWAVE SPECTRUM

There are two main types of microwave backhaul technology:

- PTP
- PMP.

Most microwave backhaul in Europe is based on PTP systems. These typically use spectrum set aside for providing PTP fixed links, which are administered by national regulatory or government authorities. Some operators also use exclusively held spectrum, acquired for example at auction, for PTP backhaul, but this is more unusual.

PMP technologies by their nature require spectrum that is allocated on a wider geographical basis (e.g. regional or national), as signals are transmitted to multiple points rather than from point to point. Regulators have made available spectrum for multipoint systems in several frequency bands, and in some cases, blocks of spectrum have also been issued on technology neutral basis in bands that are suitable for PMP microwave backhaul.

This section reviews trends in demand and supply of spectrum suitable for the development of PTP and PMP microwave backhaul systems.

### PTP

In Western Europe, many mobile operators make extensive use of PTP fixed links in their backhaul networks. Historically, bands below 10 GHz were used, because of their range advantages (longer distances can be covered compared with higher frequencies) and because they are less susceptible to rain attenuation. However, fixed links have been introduced in bands above 10 GHz, to cater for growth in mobile network traffic. In Europe, the main bands used for PTP fixed links are the 10.5, 13, 15, 18, 23, 26, 32 and 38 GHz bands, although not all bands are not used in every market.

Demand for PTP fixed links is increasing, as mobile broadband network traffic growth continues unabated. In Germany, for example, the total number of PTP fixed links rose by more than 5% over the six months to May 2010, and the regulator Bundesnetzagentur expects demand for fixed links to increase by 250% following the auction of 800 MHz and 2.6 GHz access spectrum in May 2010.

In a number of countries, certain frequency bands used for PTP fixed links, such as the 13, 15 and 23 GHz bands, are becoming congested. As a result, there are cases in some urban areas where demand for fixed links in specific frequency bands cannot be met and alternative frequencies must be used. For example, in the Netherlands, some requests for links in the 15 GHz band in areas of high demand are being accommodated instead in other frequencies, such as the 18 GHz band, and the 26 GHz is also becoming more congested. Similarly in Germany, the regulator reports a scarcity of available radio channels in some high population areas, such as the Rhine-Ruhr metropolitan region, in the 13 GHz and, more recently, the 23 GHz frequency ranges.

Despite instances of localised congestion in some frequency bands for PTP fixed links, our research indicates that many mobile operators in Western Europe can at present obtain the fixed links they need for their microwave backhaul networks and do not consider spectrum congestion to be a significant issue. Regulatory endeavours to increase spectrum availability seem generally to be keeping pace with growing demand. In the UK, for example, the auction of spectrum in the 10, 28, 32 and 40 GHz bands in 2008 appears to have released sufficient spectrum to satisfy medium-term demand for microwave frequencies.

However, the sub-40 GHz bands are expected to become increasingly saturated in future, as mobile broadband traffic rises and operators introduce LTE networks over the next three to five years. In particular, it will become increasingly difficult to accommodate the wide bandwidths required for LTE backhaul in the existing PTP fixed link bands.

To meet future demand for high-capacity fixed links, regulators are opening up higher frequency bands, such as the 40 GHz and 80 GHz bands. Table 1 summarises the availability of these bands for PTP fixed links in selected Western Europe markets.

***Table 1: Availability of 40 GHz and 80 GHz frequency bands in selected Western European markets [Source: Innovation Observatory]***

| Country | 40 GHz band | 80 GHz band |
|---|---|---|
| **France** | Authorisation regime to be developed according to market demand. | Consultation concluded in early 2010. Band to be released for FDD fixed systems in 2H 2010. |
| **Germany** | Planned to be made available for PTP fixed links. | Planned to be made available for PTP fixed links. |
| **Netherlands** | To be opened following an amendment to the National Frequency Plan in late 2010. | Expected to be opened in or after 2011. |
| **UK** | Six national licences auctioned in 2008. Awarded on a technology- and service-neutral basis. T-Mobile and Orange each acquired one licence, with UK Broadband winning the remaining four. | Available under light-licensed process for PTP fixed applications. |

The 40 GHz band has already been released in the UK, where six national licences were awarded in 2008, as part of a wider auction of spectrum that also included frequencies in the 10 GHz, 28 GHz, and 32 GHz bands. France, Germany and the Netherlands also plan to open the 40 GHz band for fixed service to address demand for high-capacity links.

There is growing interest among mobile operators in Europe in using the 80 GHz 'millimetre wave' frequencies to provide backhaul for LTE networks at urban and other traffic hotspots. This band has several attractions in this regard:

- Very high capacities can be supported, albeit over limited distances
- A high degree of frequency reuse is possible, allowing a dense configuration of links without interference issues
- A light licensing regime is used in many countries, making links cheap and quick to obtain. For example, in the UK links cost just GBP50 a year.

PTP backhaul equipment is available for the 80 GHz band from a number of vendors but, while the technologies are mature, equipment costs are high. In addition, because the range of links in this band is limited, the microwave backhaul network will need replanning, which is a time-consuming and costly exercise. Operators will need to consider carefully the overall costs of deploying fixed links in the 80 GHz band, and weigh these up against other alternatives such as PMP backhaul.

Unlicensed spectrum can also be used for backhaul purposes. The 60 GHz band, for example, which is harmonised on a global basis, offers large amounts of bandwidth, and is suitable for high-capacity links over short distances. However, two factors detract from the attraction of this band for backhaul purposes:

- The effects of atmospheric attenuation (rain and oxygen absorption) are severe in this band, and rain or humidity can cause a significant reduction in signal strength even over short distances.
- The licence-exempt approach envisaged for this band may not provide operators with the reliability they require for their backhaul networks. While the high atmospheric absorption that typifies the band mitigates the risk of interference from other users, the possibility of interference between co-channel, co-located systems cannot be eliminated.

Within Europe, there are plans to open additional frequencies in the 60 GHz band in the UK in the near term. Conversely, a consultation in France concluded that there was insufficient interest to open the band at present.

## PMP

While some frequency bands used for PTP fixed links, and particularly those below 23 GHz, are becoming saturated in some locations, spectrum suitable for PMP applications is relatively under-utilised in many European markets and has historically been inexpensive to obtain.

In the past, the focus in Europe in terms of multipoint applications was on FWA systems providing services directly to end users, and spectrum was made available in the 26 and 28 GHz bands for this purpose. However, interest is growing in the potential for using the multipoint bands for PMP backhaul systems.

While the penetration of PMP microwave backhaul technologies is currently low in Europe, owing to the predominance of PTP fixed links for microwave backhaul, we understand that a number of major European operators have deployed PMP backhaul technologies within their networks. We believe that multipoint technologies will increasingly be considered by operators replanning their backhaul networks .

For a number of the frequency bands identified for fixed service in Europe, including the 10.5, 26, 28 and 32 GHz bands, recommended EU channel arrangements are defined so as to allow the operation of either PTP or PMP systems. These recommendations have been adopted in some countries, paving the way for multipoint systems, but implementation is not universal.

The opportunity to use the 10.5 GHz band (in most countries, 10.15-10.3 GHz paired with 10.5-10.65 GHz) for multipoint systems is very limited. While usage of the 10.5 GHz band for multipoint systems is significant in some parts of the world, such as Africa and the Asia-Pacific region, in Europe the band has been used typically only to provide administered PTP fixed links. One exception is the UK, where 100 MHz of paired frequencies were released at auction in 2008 on a technology-neutral basis, which allows licensees to consider multipoint as well as PTP microwave technologies if desired.

The main bands in Europe for multipoint spectrum are the 26 and 28 GHz bands, and to a much lesser extent, the 32 GHz band. Table 2 summarises for key European markets the frequency bands that have been made available for multipoint systems.

***Table 2: Availability of main frequency bands suitable for multipoint systems in selected Western European markets [Source: Innovation Observatory]***

| | France | Germany | Italy | Netherlands | UK |
|---|---|---|---|---|---|
| **26 GHz** | √ | √ | √ | √ | |
| **28 GHz** | | √ | √ | | √ |
| **32 GHz** | | √ | | | √ |

Various countries have allocated spectrum in the 26 and/or 28 GHz bands for FWA systems, awarding licences on a regional or national basis in the first decade of the new millennium. In many countries spectrum supply outstripped demand, and frequencies remained unsold. In Italy, for example, where licences for the 26 and 28 GHz bands were granted on a regional basis, in only one region, Umbria, was all the available spectrum awarded. In the UK's first 28 GHz auction in 2000, only 15 of the 42 licences on offer were awarded; the remaining spectrum was subsequently sold in 2008. The auction of 26 GHz frequencies in the Netherlands also saw limited competition, with just two national licences issued, and low prices were paid.

A general trend in Europe towards technology- and service-neutral spectrum licensing means that regulators in the region may be amenable to removing technology and service restrictions from existing FWA spectrum licences to allow alternative uses, such as the operation of backhaul systems. This could be considered advantageous in terms of regulatory objectives such as achieving more efficient usage of spectrum resources as well as improving the quality of end-user services. In the UK, Ofcom has stated that the original 28 GHz licensees may apply for their licence conditions to be amended, following the award of the remaining unsold frequencies in the band on a technology and service neutral basis in 2008.

The 32 GHz (31.8-33.4 GHz) band has been identified on a global basis for fixed service, and, within Europe, ECC Recommendation (04)06 provides guidelines for block allocation based on 28 MHz slots that would allow either PTP or PMP systems to be accommodated. Germany is one of only a few countries that has so far adopted this recommendation, and thereby made frequencies in this band available for PMP systems. Applications can be made for multipoint frequencies in the 32 GHz band to the German regulator. The UK has auctioned six national licences in this band on a technology-

neutral basis, which gives the licensees the flexibility to deploy either PTP or PMP systems if desired. Elsewhere, the focus has been on opening the band for PTP fixed links.

The 32 GHz band is potentially interesting for multipoint backhaul systems, as the characteristics of this spectrum, such as propagation and rain fade, are similar to the 26 and 28 GHz bands, for which multipoint backhaul equipment is already available. It is possible, therefore, that suitable equipment for the 32 GHz band could become available, as it would not be a huge step for equipment manufacturers to retune their existing equipment to this new higher frequency, if there were sufficient demand.

Beyond the 26, 28 and 32 GHz bands, it is unclear how much multipoint spectrum will become available in Europe in the future. Spectrum bands at 40 GHz or above may possibly be considered for PMP backhaul applications, although equipment manufacturers are not as yet developing multipoint backhaul products adapted to these higher frequencies.

The 40 GHz band is designated within the CEPT countries for use by multimedia wireless systems (MWS) – terrestrial multipoint systems providing multimedia services to end users – and/or PTP fixed links, with NRAs left to determine how much spectrum is set aside for each of these types of service according to market demand. MWS has gained little traction in Europe or elsewhere in the 40 GHz band and currently the primary interest in the band is for PTP systems. However, the UK has issued national technology-neutral licences for this band, and if a sufficient number of other jurisdictions were to follow a similar approach, then there may be potential for PMP equipment vendors to develop backhaul products suitable for these frequencies.

The 80 GHz band may also offer future possibilities for multipoint systems. While the 80 GHz band is recommended at EU level for use by PTP fixed systems, national administrations are left to consider whether within their territories there is also demand for PMP applications and how these might be accommodated. The characteristics of this spectrum allow a higher density of antennas and better reuse factors than lower frequencies. While PTP backhaul equipment is commercially available for the 80 GHz band, PMP equipment vendors have not as yet begun developing suitable products.

## PRICING

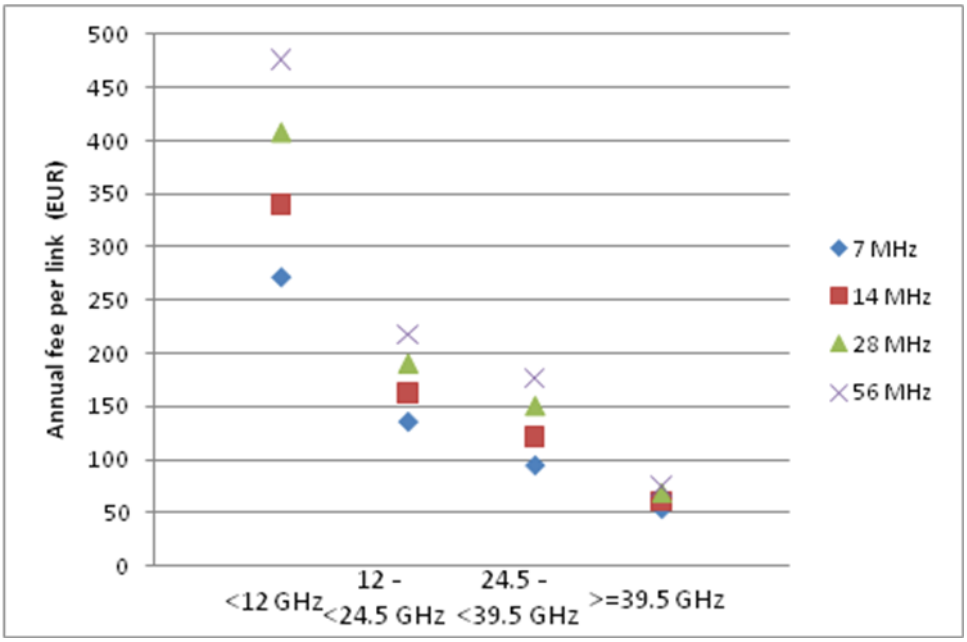
To illustrate how PTP fixed links are typically priced, Figure 3 shows the annual fees (in 2010 prices) for PTP fixed links of selected bandwidths in the Netherlands. Fixed links are most expensive in the lower frequency bands, where the overall amount of bandwidth is more limited and links can cover longer distances. Prices also vary according to the channel bandwidth required, with the wider channels more expensive.

Similar pricing structures also apply in other European countries, although absolute pricing levels vary. For example, prices in Germany are higher than in the Netherlands. In the UK, prices are based on a fixed link pricing algorithm, which takes into account factors such the channel bandwidth, the frequency band, the path length and systems availability. As an example, a 28 GHz link with 99.99% availability, a 2km path length, 28 MHz channel bandwidth and a 155Mbit/s data rate costs GBP740, whereas a similar link in the 38 GHz band costs GBP640.

Demand for higher channel bandwidths (28 MHz, 56 MHz, and above) will continue to grow as operators roll out their HSPA+ and LTE networks. As the frequency bands used today become saturated, requests for additional links will be met increasingly using higher frequency bands, such

as 40 GHz or 80 GHz. While the ongoing fees for links in these higher bands are cheaper than for lower frequency links, much shorter distances can be covered and so a greater number of links will be required. This increases the costs of other aspects of the microwave backhaul solution, as more equipment and more sites are required per km. There is an impact, for example, on both the capital costs associated with purchasing microwave equipment and with site development, and operational costs such as site rental and maintenance.

***Figure 3: Annual fees per PTP fixed link of selected channel bandwidths, Netherlands (2010 prices) [Source: Innovation Observatory]***




In contrast to PTP fixed links, multipoint spectrum, such as in the 26 and 28 GHz bands, is licensed on a regional or national basis. Licensing processes vary, and include administrative assignment, competitive tender and auction. Licences are offered for a minimum initial term, typically of 10 or 15 years, and are renewable thereafter.

Depending on how the spectrum is assigned, the price paid for the licence may be determined by the regulator (administered pricing) or reflect market perception of its value (e.g. when sold at auction). For licences acquired at auction, administered pricing applies once the initial licence term has expired. Some licences may permit secondary trading, which allows the spectrum to be resold at a price determined by the market at the time of sale.

The prices paid historically for multipoint spectrum vary according to how, when and where the spectrum has been licensed. In general, spectrum in the 26 and 28 GHz bands has been cheap to acquire, with a low level of competition for many licences in these bands. In Italy, the 2002 auction of regional WLL licences in the 26 and 28 GHz bands raised a total EUR40 million, averaging EUR0.56 million per regional licence, and only one region saw competitive bids. Meanwhile, in the UK, the 2000 auction of regional licences in the 28 GHz band raised GBP38.16 million, equivalent to an average of GBP2.5 million per licence, and only in 3 of the 14 regions defined were all licences sold. The remaining 28 GHz frequencies in the UK were successfully auctioned in 2008, raising a total of GBP320,500.

## POINT TO MULTIPOINT AS A MICROWAVE OPTION

While PTP technologies are likely to continue to be important in Europe for microwave backhaul, given their well-established role in many mobile operators' networks, we believe that operators will increasingly consider multipoint technologies during their replanning of microwave backhaul networks.

PMP equipment vendors need to take into account that operators are very familiar with using PTP microwave backhaul and much less familiar with PMP backhaul technologies. In addition, operators may have had a bad experience with legacy technologies based on PMP concepts such as Local Multipoint Distribution Service (LMDS) and this may continue to adversely colour their views.

However, PMP technologies have moved on significantly in the last five years. Mature PMP backhaul solutions are commercially available, and have been successfully deployed in the Middle East and Africa, and on a smaller scale in Europe, with tier-1 operators using the technology and reporting high spectral efficiencies in dense urban networks.

There are also signs that perceptions towards multipoint technologies are beginning to change. Although some operators interviewed for this research had a clear focus on PTP backhaul, others expressed a strong interest in the latest generation of PMP technologies. Some large operators indicated that they had already undertaken trials of multipoint backhaul solutions or planned to do so in the near term.

Multipoint backhaul technologies offer several potential benefits, including:

- **Cost savings.** PMP backhaul solutions use fewer antennas than PTP, which enables savings on the capital costs of equipment and on ongoing costs such as site rental and maintenance.
- **Speed of deployment.** Because fewer antennas are used than for PTP systems, PMP solutions can be deployed more rapidly.
- **Spectral efficiency.** Techniques such as statistical multiplexing used by PMP systems reduce the total bandwidth required, enabling an efficient use of spectral resources.
- **Spectrum availability.** Multipoint spectrum is under-utilised in many European markets, and could potentially be used for PMP backhaul applications.

Table 3 compares PTP and PMP backhaul approaches in the context of Europe, against a range of criteria, including capital costs of equipment, operational costs (including maintenance, mast rental and spectrum), capacity and range, the availability of spectrum, and speed and flexibility of deployment.

Each approach has its merits. For PTP fixed links, future development is towards higher frequency bands, which offer abundant bandwidth and capacity and low spectrum costs, but have limitations in terms of range and the costs of equipment. For PMP backhaul, there are attractions in terms of spectrum availability and cost, capital and operational costs, spectral efficiency, and time to market. However, multipoint backhaul equipment vendors need to demonstrate that their latest solutions can deliver on their promises and overcome lingering adverse perceptions associated with legacy technologies.

***Table 3: Comparison of PTP and PMP microwave backhaul approaches in Europe [Source: Innovation Observatory]***

| | PTP | PMP |
|---|---|---|
| **Costs** | Microwave equipment costs have come down in recent years. Millimeter wave spectrum is relatively cheap, but equipment is still expensive. | Fewer antennas needed than with PTP, which saves on capex and opex. Regional or national spectrum licences may be available cheaply. |
| **Capacity and range** | Lower frequency bands suitable for covering longer distances are becoming saturated, and there is limited availability of links with wide channel bandwidths. Spectrum is becoming available in higher frequency bands (40 GHz and above) to cater for rising demand for high-capacity links. These bands offer very high link capacity, but over very short distances. | The main multipoint bands (26 and 28 GHz) offer a good combination of capacity and range. Techniques such as statistical multiplexing reduce the total bandwidth required. |
| **Spectrum availability** | Fixed link availability varies according to the bandwidth and frequency band required, and geographical location. Bands below 23 GHz are becoming saturated in some urban areas, and high-capacity links are becoming more scarce in the existing fixed link bands. Frequency bands at 40 GHz and above will be opened to cater for future demand. | Multipoint spectrum in the 26 and 28 GHz bands has been released in many European markets for FWA and is under-utilised compared to PTP fixed link bands. Uncertain what additional bands will become available for multipoint backhaul in future. |
| **Speed and flexibility of deployment** | Administered fixed links can be acquired rapidly. Licence-exempt or light licensing processes for the 60 and 80 GHz bands reduce spectrum costs and speed time to market. | Multipoint technologies use fewer base stations than PTP systems, which speeds time to market. Exclusively held spectrum can be flexibly deployed, to add links as demand evolves. |

PMP backhaul requires suitable multipoint spectrum available in Europe both now and in the future and we believe that there are a number of spectrum opportunities that enable operators to consider deploying PMP backhaul solutions:

- Existing multipoint spectrum, such as in the 26 and 28 GHz FWA bands, is under-utilised and is generally cheap to obtain. Unused frequencies could potentially be used for backhaul applications, subject to regulatory approval. Regulators are increasingly adopting a technology neutrality approach to spectrum licensing, and may be amenable to allowing a more liberalised use of these bands.

- Operators should keep an eye open for auctions of suitable frequencies (e.g. in the 26, 28, or 32 GHz bands) on a geographic basis, with technology and service neutral licensing conditions. This approach was adopted by the UK, for example, for its auction in 2008 of spectrum in the 10.5, 28, 32 and 40 GHz bands.

- A number of countries, including Germany, has adopted EU guidelines for the block assignment of spectrum in the 32 GHz band, and made it available for PMP applications.

To increase operators' options for microwave backhaul now and in the future, regulators should consider:

- Making unused spectrum in the 26 and 28 GHz bands available on a technology and service neutral basis, and amending existing licences to remove restrictions
- Adopting EU guidelines on the block allocation of frequencies in the 32 GHz band, so that PMP as well as PTP systems can be accommodated
- Studying the demand for multipoint backhaul systems in other bands identified for fixed service, such as the 40 and 80 GHz bands.

Because suitable multipoint spectrum can be obtained in many markets, PMP solutions are a viable alternative to PTP fixed links for microwave backhaul expansion, and offer an attractive solution in terms of a combination of costs, coverage and capacity.

## CONCLUSIONS

Microwave backhaul has an important ongoing role in European operators' mix of backhaul technologies. PTP fixed links are the dominant solution for microwave backhaul, and will continue to be used in future. However, European operators need to make use of a variety of technologies if they are to optimize their networks: PMP should be a part of the mix where spectrum for P2P links is becoming scarce or expensive.

The spectrum currently available for PTP fixed links will become increasingly saturated as operators' 3G/4G network traffic rises, driving the deployment of links in the frequency bands at 40 GHz and above to cater for operators' growing requirements for backhaul capacity. Higher frequency bands, such as the 80 GHz band, offer very high capacities, but over limited distances, and equipment is at present costly.

The availability of low-cost, sub-40 GHz multipoint spectrum in many markets, combined with mature PMP technologies proven in commercial deployments, provides an opportunity for operators to consider the merits of deploying PMP backhaul solutions as part of their overall microwave backhaul strategy. In particular, the main multipoint bands of 26 and 28 GHz bands could offer an attractive combination of range, capacity and cost benefits for operators' backhaul extension.